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## Psychomotor speed as a marker for overtraining in athletes

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# **General discussion**

The hypothesis that psychomotor speed is an early marker for overtraining was, at least partly, confirmed. In chapters 3 and 4 proof for longer reaction times in early stages of overtraining has been found. In chapter 3 five cyclists were FO after their training camp. Their reaction times on the FPT were longer than before the training camp. The other two groups, the well trained cyclists and the control group, showed shorter reaction times on the FPT after this period. However, the differences were not significant. In chapter 4 it was shown that rowers who report lower perceived performance have significantly longer reaction times on the DT. Some indication for cross-sectional differences in reaction time on the DT between an NFO and a healthy athlete have been shown in chapter 5. Thus, from this evidence one could conclude that psychomotor speed is an early marker.

From chapter 2 it can be concluded that the usability of tasks of psychomotor speed in sports practice is good. Although the purpose of that chapter was not to show practical usability of the FPT, from the data this conclusion can be drawn anyway. Subjects showed shorter reaction times on the FPT after a maximal exercise bout, even when this was done twice a day. Results from an earlier study show that reaction times on the DT are unaffected by exercise (Lemmink & Visscher, 2005). This shows that no false positive (i.e., an athlete is unjustly warned for overtraining) conclusions can be drawn when performing tasks of psychomotor speed after a practice session. However, the effect of time of day nor the effect of performing such tasks in different environments and/or on different computers have been investigated. Before tasks of psychomotor speed can be included in, for example, an internet monitor, we must be sure that these factors will not lead to false positive conclusions either.

A notable aspect of the presented studies is the difference between chapters 3 and 4 in the reaction time task that showed changes in early stages of overtraining. In the high load training study, presented in chapter 3, the FPT showed changes in reaction time but not the DT. In the monitor study, chapter 4, differences were found on the DT but not at the FPT. Differences between the two studies might help to explain these contradictory findings.

An important difference between the studies is the difference in periodisation of training load. In the high load training study there was a clear periodisation. The cyclists were tested before and after a training camp and after two weeks of recovery training. The training load of these cyclists doubled during the training camp. In the monitor study the measurement moments were further apart and hence a clear periodisation between the measurements was not present. A group of rowers was followed during a regular season. They were tested at five time points throughout the season. Although I don't have information on the training load of these rowers, it is unlikely that at a certain time point the load doubled.

Performance of the cyclists in the high load training study was assessed with a maximal exercise test. Only the cyclists who did not perform well after the training camp and showed changes in mood state or perceived stress and recovery were classified as FO. In the monitor study perceived performance was assessed using five questions. It is unknown

how the performance assessment in the high load training study relates to the performance assessment in the monitor study. For now it can only be concluded that the FPT seems sensitive to sudden changes in training load, whereas the DT seems sensitive to small changes in perceived performance.

The next question then is, what makes the FPT so different from the DT? In the discussion of chapter 4 it was already pointed out that both tasks measure different aspects of reaction time. In the DT an emphasis is placed on stimulus identification and response selection. This task consists of five different visual/manual stimulus response combinations, two visual/pedal stimulus response combinations and one auditory/manual stimulus response combination. On the other hand, in the FPT the emphasis is on selective stimulus detection and selective response preparation. However, in chapter 2 it was concluded that the facilitative effects of exercise on reaction time must be due to facilitation of the motor component, as no interaction with pre-cue condition was found. The same could therefore be concluded for the debilitating effect of FO. It must be due to changes in the motor component as no interaction with condition has been found. However, like in an earlier study (Rietjens et al., 2005), the difference in reaction time was largest at the uncued and the neither cued conditions. This interaction did not approach significance, probably because of the small number of FO cyclists. It can therefore not unambiguously be concluded that the psychomotor slowness was only present in the motor component. Future studies should reveal what aspect of information processing is affected, to which factor the psychomotor slowness can be attributed.

Apart from the different aspects of information processing that are emphasised in both tasks another difference should be noted. The FPT is always self-paced. The next trial starts one second after each response. In the first part of the DT, the action mode, the next stimulus appears immediately after a correct response has been given. Thus, in the action mode of the DT the subject never gets a moment of rest, whereas in the FPT one second breaks are present between each trial.

In the second part of the DT stimuli appear with fixed intervals. The presentation time of the stimuli becomes increasingly shorter, putting subjects under pressure. The NFO subject in chapter 5 showed decreased performance at blocks with short presentation times. It seemed that she was unable to perform under pressure. The same pattern can be seen in chapters 3 and 4. Reaction times in the blocks with the shortest presentation times were slightly longer. As in both studies no interaction with block was found, it must be concluded that this pattern did not change over time.

Thus, although several differences between the studies described in chapter 3 and 4 and several differences between the two reaction time tasks have been described, it is hard to conclude what caused the contradictory findings. An interesting aspect in the FPT is the finding that the most complex conditions seem most affected. The largest changes occurred in the uncued and the neither cued conditions (Rietjens et al., 2005; chapter 3 of this thesis). Still the overtraining was rather asymptomatic. In the study in chapter 3 only small changes in performance were found, whereas Rietjens et al. (2005) did not even

show changes in performance. In both studies small changes in mood state were found. The finding that reaction times became longer just at the most complex FPT conditions is consistent with the threshold theory (Satz, 1993). Satz proposed that brain lesions can be detected when they are still asymptomatic using challenging assessment techniques. Remember from chapter 1 that Satz's threshold theory shows similarities with Kenttä and Hassmén's (1998) conceptual model. They proposed that an athlete's stress capacity determines at which stress regeneration ratio problems of overtraining will occur. As it is not possible to measure stress capacity nor the exact stress recovery ratio, the challenge lies in detection of sub-threshold conditions. Results of the present dissertation showed that tasks of psychomotor speed might be such assessment techniques.

Does this mean that these tasks can readily be implemented in sports practice? Unfortunately, I can not answer this question positively. At this moment, there are still too many uncertainties. In the studies described in this dissertation, reaction times were assessed under highly standardised conditions. The tasks were performed in a quiet laboratory, with standardised equipment. As was pointed out earlier in this chapter, it is unknown what the influence of different environments and/or on different computers is on reaction time. Another problem that arises is the practice effect. It is generally known, and I have indeed found it in all my studies, that reaction times become shorter as the task is performed repeatedly. This effect is robust and can be present even with many weeks between assessments, as was seen in chapter 4. This effect is also unpredictable. Reaction times on the FPT in chapter 2 kept becoming shorter even over 12 assessments in three weeks time (this effect was not tested for significance), while reaction times on the FPT in chapter 4 only became shorter from the first to the second measurement. These uncertainties in combination with the puzzling difference in results between studies make it too early to use psychomotor speed as a marker for NFO or OTS.

Apart from the practical issues that need to be resolved a more fundamental research question should be addressed in future studies. What changes in the brain cause the psychomotor slowness associated with overtraining? A combination of different (neuro-imaging) techniques should be used to answer this question. Additionally, such studies could help to find directions for treatment. At this moment, the only known treatment is rest, as is the case for many other stress related syndromes.